Hybrid Robotic Mobile Platform

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INTRODUCTION

Robotics is versatile field with the ultimate goal of improving the human experience. Robotics are designed to perform a number of functions and are quickly becoming and integral part of human society, specifically for exploration and education. With this mind, there is a need for robotic systems with flexible components that can better mimic human or animal biology. This can be achieved through the use of soft robotic components or smart materials, specifically soft actuation. Soft actuation can be described as the use of compliant, flexible materials that allow a device to move or operate. This project explores the use of liquid-based electroactive polymer (EAP) actuators, as the mechanism to drive an exploratory robotic platform that mimics the locomotion of a snake.

GOALS

- **Develop a flexible and durable robotic platform designed to traverse unique terrains and extra-planetary environments.**
- **Fabricate EAP actuators to drive the motion of the platform.**
- **Study the physical motion of the platform.**
- **Investigate the actuator mechanism and materials.**
- **Study and design an autonomous control system for the actuators and the robotic platform.**

METHODS

- Research the structure of reptile skin, to develop a method for the platform to navigate unique environments.
- Study the locomotion of snakes, to mimic the motion with liquid-based actuators.
- Investigate different geometries and materials for the actuators.
- Model the actuator to understand the underlying physics, predict the power requirements, and displacement outputs.
- Model the motion in response to the actuators.
- Design and fabricate a prototype platform.

METHODS CONT'D

- Modelling:
  - The dynamic motion of the platform was modelled in MATLAB, using computational methods (Figure 1).
- Fabrication and Testing
  - The actuators are fabricated using a flexible polymer film which holds a liquid dielectric, and flexible electrodes (Figure 2).
    - Fundamentally, the actuators use the principles of electrostatics and hydraulic actuation, the actuator uses a compliant electrostatic actuator to move fluid in a flexible shell and cause a displacement (Figure 3).
    - For electrostatic actuation, there is a dielectric medium between two electrodes; as the electrodes are activated, the electric charge in the dielectric aligns and the oppositely charged plates are drawn toward each other.
    - In the case of hydraulic actuation, a fluid is moved in a vessel and the causes the movement of a component.
  - The chassis of the platform as been fabricated using additive manufacturing (Figure 4).
  - Different film materials are being tested to optimize the durability and functionality of the actuator (Figure 5).
  - Simple blocking force and displacement testing as taken place as well.

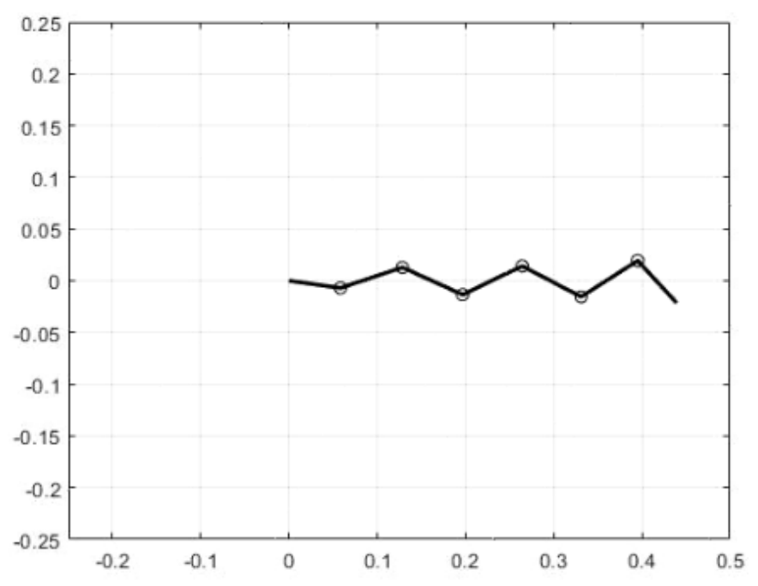


Figure 1: The simulated motion of the robotic platform at time t= 10.38 seconds.

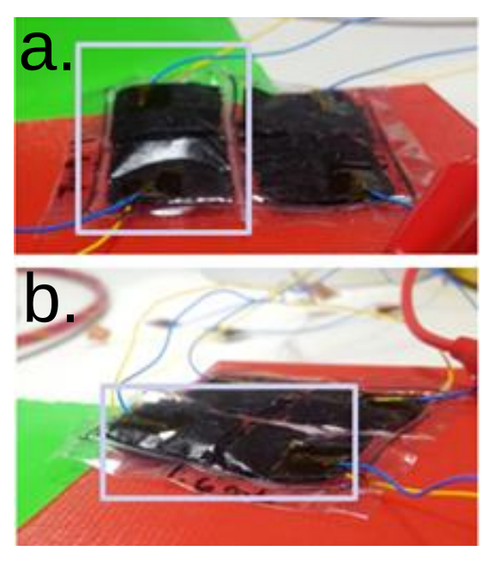


Figure 2: Prototype actuators activated mode.
a. Top view
b. Side view

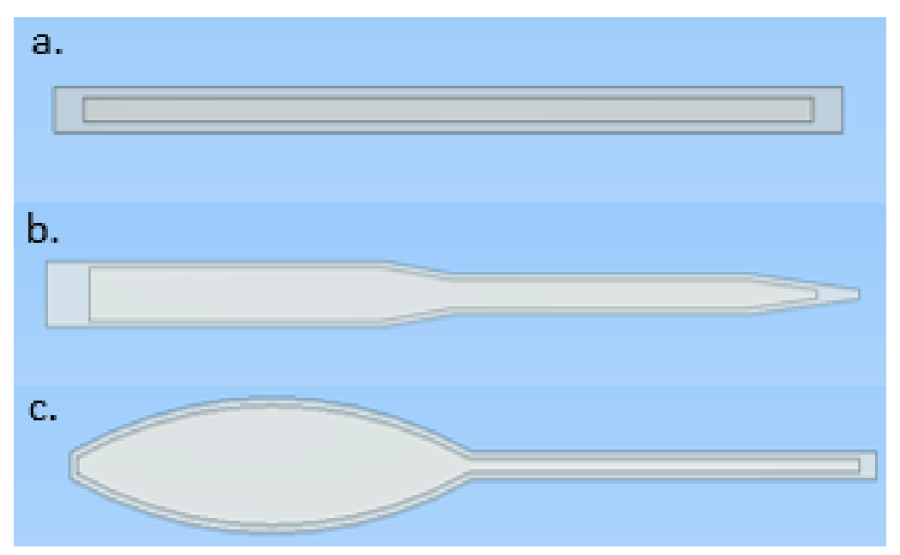


Figure 3: SolidWorks model of the HASEL actuator in the various activation modes. The figures above display the cross-section view.
a. The actuator when no voltage is applied.
b. The actuator when the critical voltage has been reached and the electrodes are beginning to be drawn together. The fluid is beginning to displace.
c. The actuator when the electrodes are fully closed and the fluid is fully displaced.

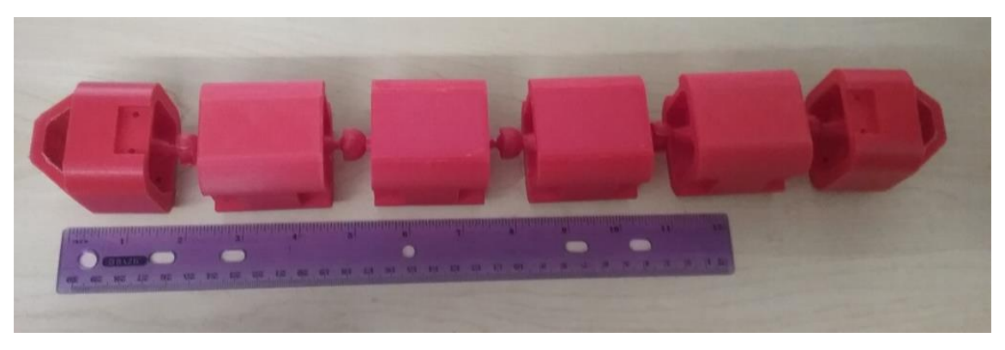


Figure 4: Prototype chassis for the robotic platform. The material used is Polylactic Acid (PLA).

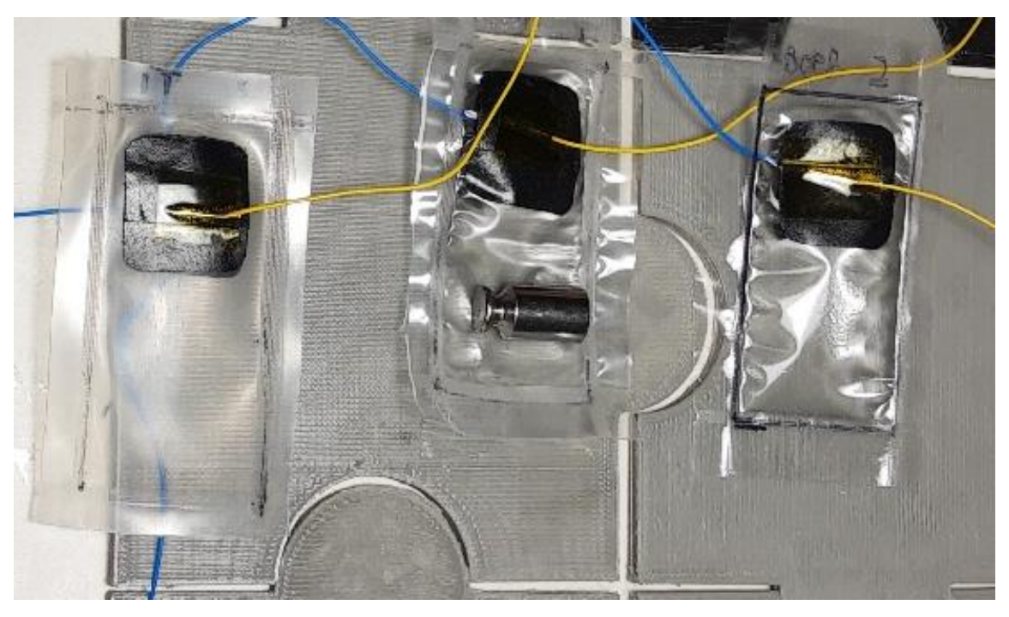
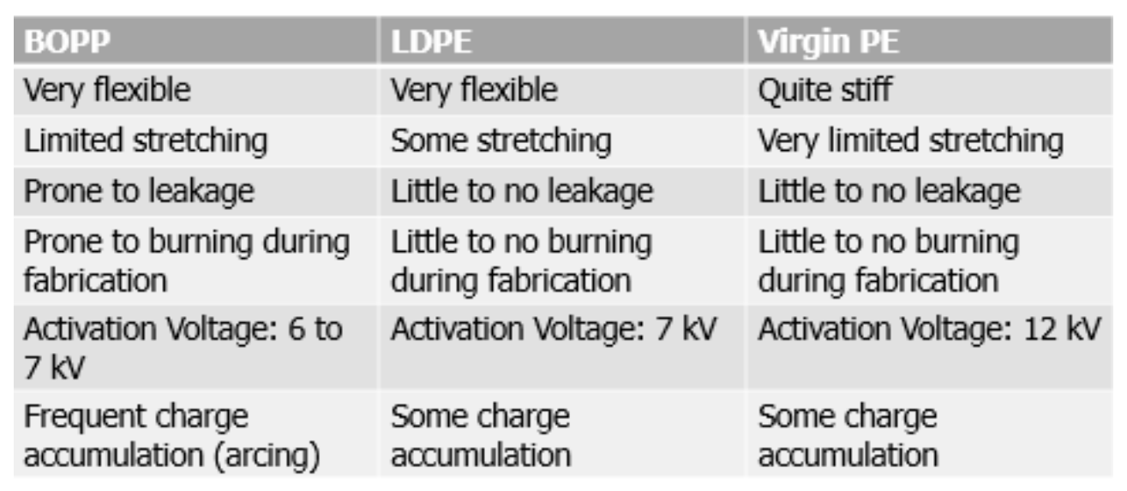


Figure 5: Test of different films. From left to right: Virgin Polyethylene (VP), Low-Density Polyethylene (LDPE), and Biaxially Oriented Polypropylene (BOPP).

RESULTS

- Modelling:
  - The applied forces and torques of the MATLAB model are over-simplified, so the current work looks to better define these applied forces and torques.
- Fabrication and Testing:
  - The current actuators use a thin film with thickness on the order of 0.5 mm.
  - By testing different film materials, the best material was found to be the LDPE (Table 1).
  - A single actuator unit could lift about 32 grams at a displacement of about 2 mm.



BOPP	LDPE	Virgin PE
Very flexible	Very flexible	Quite stiff
Limited stretching	Some stretching	Very limited stretching
Prone to leakage	Little to no leakage	Little to no leakage
Prone to burning during fabrication	Little to no burning during fabrication	Little to no burning during fabrication
Activation Voltage: 6 to 7 kV	Activation Voltage: 7 kV	Activation Voltage: 12 kV
Frequent charge accumulation (arcing)	Some charge accumulation	Some charge accumulation

Table 1: This table list the criteria used to determine the best film.

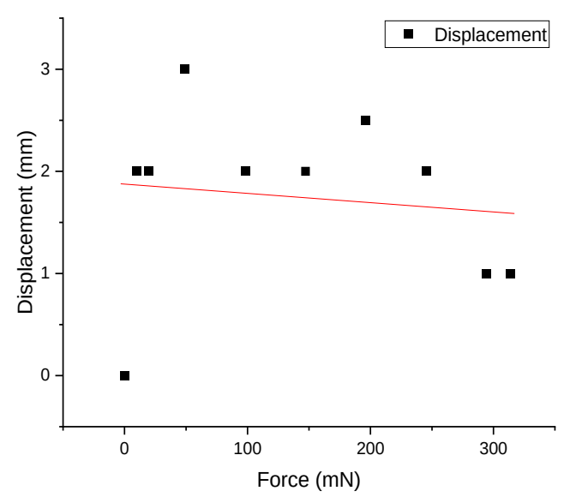


Figure 6: Displacement vs Applied Force

CONCLUSION

The Hybrid Robotic Mobile Platform is a robotic platform designed for exploration and education. To better suit the needs for exploration, the platform uses novel liquid-based actuation and a snake-like locomotion, for ease and flexibility. This platform seeks to better understand soft robotic and how robotics impacts the world.

FUTURE WORK

- **Continue working on the dynamic motion model, by improving the input force conditions.**
- **Improve the actuator mechanism by considering different geometries.**
- **Continue building the physics-based model of the actuator.**
- **Investigate electrical and control systems for the platform.**

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